REASONING USING NEWTON'S LAWS – SOLUTIONS

1. FALSE. Read the statement carefully. *The force exerted on the horse by the wagon must be equal and opposite (true) to the force exerted on the wagon by the horse.* The key here is that the forces are exerted on two different bodies.

   Draw an FBD for the horse. You should have at least the F_g, F_N and F_{wagon}. In order for the horse to move forward, there must be an applied force (from the ground pushing forward on the horse as it pushes back) that is equal or greater than the force of the wagon. According to Newton's 1^{st} and 2^{nd} Laws, the normal and gravitational forces cancel each other out. The applied force exerted forward by the ground on the horse (equal to that by the horse on the ground – 3^{rd} law) would then propel the horse forward. Same concept applies to the wagon.

2. FALSE. In order for the ball to bounce off of the wall, there must be a force exerted by the house on the ball. The ball in turn exerts the same force on the house (3^{rd} Law). Why doesn't the house move? The force of the ball on the house cannot exceed the frictional force experienced by the house.

3. TRUE. Let's ignore the lower block for the moment. The upper block experiences a gravitational pull down by the Earth (force 1). As the block is not moving, according to Newton's 1^{st} and 2^{nd} Laws, the string connecting the block to the 'ceiling' would then be under tension and the magnitude of this tension would have to equal that of the block's weight as F_{net} would then be zero. Now attach the lower block to this system. It's weight acts, through its string, onto the upper block, pulling it down. The tension in the upper string now has to increase to compensate for this additional force (Newton's 1^{st} and 2^{nd} Laws).

4. FALSE. To simplify the analysis, both individuals are on an ice surface – thus frictionless scenario. If the father pushes on her with a force A, then she pushes back on him with a force A (Newton's 3^{rd}). FBD's would show then that this force A would be the net force each of them experiences. As he has a larger mass (inertia) – Newton's 1^{st} Law – then he would accelerate at a lower rate – Newton's 2^{nd} Law. In a similar fashion, the lower mass of the daughter would result in her accelerating faster. If the daughter were to do the pushing and, assuming that she pushed just as hard as the father did, we would observe the same accelerations once more.

5. While the spring exerts a force on both blocks, that force that it exerts is the same (Newton's 3^{rd} Law). As it exerts a force on the smaller mass, the smaller mass exerts a force back, through the spring, onto the larger mass. As both are on a frictionless surface, this applied force is equivalent to the net force (horizontally) that each block experiences (2^{nd} Law) and the larger block will then experience a lower acceleration.

6. (A) The normal force on the left block is the greatest in case I as the block has a larger mass and hence a greater gravitational pull. The surface then has to exert a greater upward force in order for the vertical forces to be balanced.

   (B) The tension in rope 1 is the same in either case. Think of the two masses as a 'system'. Rope 1 still has to overcome the friction experienced by the two masses combined. As the speed is constant, the tension must be of the same magnitude as the friction experienced.

   (C) Rope 2 is pulling a larger mass in case II than it is in case I. The larger mass creates greater friction than the smaller mass. As both objects are moving at the same speed in each situation, then rope 2's tension in case II must be greater than in case I in order for the forces to balance. Remind me to discuss this further after we look at friction more closely.

   (D) Ignoring F_{air} and knowing that the force of friction between the two surfaces does not depend on speed, then the tension in rope 1 is the same in both cases (as per (B)).

7. (A) *Situation 1*. Draw an FBD for block A and for block B. As both blocks have the same *weight* you should be able to deduce that the tension on each 'side' of the string will be the same, just in opposite directions. The system will not move.

Situation 2 An FBD for block A will be the same as in (A). The tension is transmitted to the wall (which replaces block B). The wall pulls on block A with the same tension as the block pulls on the wall (Newton's 3^{rd}). The system will not move.

Situation 3 Again, FBD's shed light ono the matter. The tension experienced to the left on block C will be identical to that experienced by block A (3^{rd} Law). The tension experienced to the right on block C will be the same as that experienced by block B (3^{rd} Law). Since block A and block B have the same mass, the two tensions on block C will be the same and will cancel eachother out. Thus, no movement.

(B) The tension in the string is the same in all three situations. Think about it. Don't get it? Come in and see me.

(C) As both masses are the same, the friction experienced by C will be the same from either side and each will negate the other. In fact, in this situation, its is impossible for any friction to be present. You will see why shortly.